are not such as to cause a *positive* after-image in the left eye, that being caused only by a relatively bright light or in a well-rested eye. In the given circumstances, it cannot be detected with the right eye closed. Moreover, this after-image can be got, though with more difficulty, even if the left eye is kept open, provided the bit of bright paper is cut off by a piece of card-board; but these are conditions under which, according to all that we know about after-images, only negative ones can arise in the affected eye. Ebbinghaus does not suppose that in this phenomenon an actual effect is produced in the right retina, but rather that it is due to central processes; and in supposing this he does not consider that the well-founded belief that ordinary after-images are peripheral is at all affected.

The hypothesis that an excitation of one eye produces an effect in (at least the central attachments of) the other eye, Ebbinghaus considers is borne out by other facts. In binocular color-mixing, *two* colors are produced which succeed each other by rivalry; even when the colors mixed are nearly alike and the composed color looks like one, it will be found, on trying to match it with pigments, that it is really two. Ebbinghaus' hypothesis here is that the two eyes see two distinct images, A and B, and at the same time two faint, sympathetic images, *b* and *a*; and that rivalry takes place between the fused pairs, *A*, *b* and *B*, *a*, the color of the mixture thus leaning now towards one and now towards the other of the component colors. [This is the same thing as saying that a real *binocular fusion*, in the original meaning of the phrase, does not take place at all.] A similar explanation is applied by Ebbinghaus to binocular contrast.

The new phenomenon described is difficult to get and Ebbinghaus recommends trying it, for the first time, after a sleepless night.

C. L. F.

*Optische Urtheilstäuschungen.* Dr. F. C. MÜLLER-LYER. DuBois-Reymond's Archiv. Supplement Band, 1889.

The interesting illusions described and explained in this article are difficult to understand without the accompanying illustrations. If we draw an acute angle and an obtuse angle with equal sides, the sides of the latter will seem very much longer than the sides of the former, and this effect will be the more marked the greater the difference in the two angles. Again, draw a pair of such angles and connect their apices by a straight line, and the straight line connecting the obtuse angles will seem longer than the one connecting the acute angles, that is, provided the sides of the angles are directed towards the connecting line; if they are directed away from this line, then the line connecting the acute angles seems the longer, and the contrast becomes strongest in comparing two lines connecting pairs of acute angles, alike in the size of the angle and the length of the sides, but the one directed towards, and the other away from the connecting line. The same illusion appears in various forms: the sides of a triangle seem smaller than the sides of a square, though really the same; and the sides of the square will seem shorter than the equally long sides of a pentagon or hexagon, and so on. The general principle of explanation is, that the more contracted the suggested environment of the space-dimension in question, the smaller will it seem. This explains at once why the sides of acute angles seem shorter than those of obtuse ones, why lines with contracting angles or curves seem shorter than lines with expanding outlines at their extremities; why a space between two narrow oblongs seems larger than the same space between two squares, or a distance on a line marked off between two short lines seems longer than the same distance marked off between two longer lines, and so on. It is also to be noted that these illusions differ from the ordinary effects of contrast in that

while in contrast the stronger effect weakens the effect it accompanies, here the reverse holds true. With these are connected two other types of illusions, the one referring to the change of form of the contour of an interrupted figure, as when a portion of the circumference of a circle is omitted; the other to the contrast induced by placing the smaller side of one of two equal figures next to the larger side of the other figure, and thus causing the first to seem smaller, etc. These illusions are all clearly marked, have a wide field of application, and promise to repay further study. J. J.

*Das Netzhautbild des Insectenauges.* Prof. SIGMUND EXNER. Repertorium der Physik, Bd. XXV, H. 9 und 10, 1889; also Sitz.-Ber. der Wiener Akad. (3 Abth.) Bd. 98 (1889).

In this paper, which in some sense corrects and completes an earlier one on a similar subject, Prof. Exner seems to have definitely settled the question as to whether insects with compound eyes see by means of a single erect image, (Johannes Müller's view), or by means of a multitude of little inverted images, (as held by several later observers), and to have settled it in favor of the earlier view, at least with modifications. By taking the eye of the male firefly (*Lampyris splendidula*), (the same might be done with the American *Elater noctilucus*), replacing the softer parts with diluted glycerine, and mounting it under the microscope (power of 60-100) in such a manner that the convex surface was free to the air as in life and the focal plane of the microscope lay in the place once occupied by the retina, he was able to observe the image directly, and by focussing up and down to study its nature and formation. The dioptric unit of the compound eye in this insect consists of a crystal cone (*Krystallkegel*), the lower end of which is rounded into a lens-like point, and of the attached corneal facet, also lens-shaped. This crystal cone, assisted somewhat by the lens-forms at its ends, but depending in large measure on its own peculiar refractive powers, behaves like a minute astronomical telescope and projects an erect image of the portion of space to which it is directed on the retinal elements lying below it. The neighboring cones also project similar images, each differing slightly because of the different directions of the cones. The points of these images that represent the same objective points in space coincide, and thus form a "summation image," which was that observed by Exner. In the eye of *Lampyris* as many as thirty cones contribute to the "summation image" of a small light object. The peculiar refractive powers of the cones rests in the increase of the refractive index in successive strata from the convex surface toward the axis. To account for the presence of large quantities of pigment in the space between the crystal cones and the retina in some insects and its absence in others (*e. g.* these fireflys) the author offers this hypothesis, which in a later paper (*Sitz.-Ber. der Wiener Akad.* Bd. 98, (3 Abth.,) v. 21 März, 1889.) he has substantiated by observation, namely that when the eye is exposed to light the pigment spreads backward from the region of the cones into the otherwise free space. The effect of this would be to cut off as it advanced more and more of the single images going to form the "summation image," proportionately reducing its intensity; it would thus serve the same function as the iris in the eye of higher forms. The author by no means believes that the eye of *Lampyris* is typical of all composite eyes, though the understanding of it is an advance; indeed he devotes a section to the consideration of other forms in which the structure is different. For these details, however, and for very much information not easily abstracted, or not of immediate interest here, *e. g.*, the other optical images to be observed in addition to that mentioned above, the physico-mathematical consideration of the crystal cones, the measurement of the eye, the